Magnetic resonance imaging in acute appendicitis
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Chapter 6

MRI for clinically suspected appendicitis during pregnancy

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Abstract

OBJECTIVE. The purpose of this study was to evaluate whether magnetic resonance imaging (MRI) can accurately diagnose or exclude appendicitis in pregnant patients with clinically suspected appendicitis.

CONCLUSION. Our results suggest that MRI is helpful in the examination and diagnosis of acute appendicitis in pregnant patients. MRI may therefore be a good alternative to CT in pregnant patients for whom US findings are non-diagnostic.
Introduction

Acute appendicitis complicates approximately 1 of 766 pregnancies [1] and is the most common nonobstetric surgical emergency in pregnancy. Many more laparotomies are performed for the suspected diagnosis implicating a negative laparotomy rate of 25 to 50% [1-3]. Acute appendicitis in pregnant women, particularly when perforation with peritonitis occurs has been associated with premature labour and fetal and maternal death [2]. Alteration of the position of intra-abdominal contents by the pregnant uterus can make clinical symptoms difficult to interpret (3).

Transabdominal sonography [4] and abdominal CT [5] have proven to be reliable procedures for detecting or excluding appendicitis and have reported sensitivity and specificity of more than 90%. Sonography is highly operator-dependent, and is hampered by obesity or the presence of bowel gas; CT exposes the fetus to a considerable amount of radiation. The routine use of diagnostic CT examinations for benign diseases, such as appendicitis, raises the question whether the diagnosis can be obtained by other radiological means, particularly in young patients and pregnant women. Abdominal MRI appears to be an alternative. MRI has been described as a valuable technique for the evaluation of patients with suspected acute appendicitis [6], so this study was carried out to evaluate whether MRI could also be used to accurately diagnose and exclude appendicitis in pregnant patients with clinically suspected appendicitis.

Materials and methods

A total of 284 patients were referred to the radiology department at our 300-bed community hospital from January 2000 to January 2003 because of clinically suspected appendicitis. The policy at our hospital is to perform a sonographic study on every patient with acute abdominal pain. Twelve of the 284 patients were pregnant;
they underwent MRI and form the study group. The medical ethics committee of the hospital approved the study, and written informed consent was obtained before MRI. The final diagnosis was made on the basis of clinical and sonographic findings, surgical findings, pathology examination, and patient follow-up. MRI was performed on a 1.0-T system (Harmony, Siemens). Breath-hold T1-weighted fast low-angle shot (TR/TE, 133/5.5; flip angle, 75°), T2-weighted turbo spin-echo (3,300/108; flip angle, 160°), and T2-weighted turbo spin-echo fat-suppressed (3,360/108; inversion time, 160 msec) sequences were obtained using a body phased-array receive coil. A multislice imaging technique was used for all patients, with 5-mm-thick slices and a distant factor of 0.5 mm and acquisition times of 13–24 sec. The study protocol was designed to be as noninvasive as possible, so usually no gadolinium was administered. Using only breath-hold sequences meant that the total room time for each MRI examination was less than 20 min, during which time the patient was also registered and the images were reviewed for technical adequacy.

The MRI criteria for appendicitis included an enlarged appendix with a diameter of more than 6 mm and signs of periappendiceal inflammatory changes. The MRI criteria that excluded appendicitis were a normal appendix of less than 6 mm or an appendix with a diameter of more than 6 mm with no evidence of periappendicitis. All MRI studies were performed within 1 hr after the sonographic studies. In a clinical setting, a radiologist experienced in abdominal imaging prospectively interpreted the MRI studies without reference to the sonographic studies. The final treatment of the patient was based on clinical, sonographic, and MRI results. Two radiologists also retrospectively reviewed the MRI studies together to reach consensus for possible differences in interpretation.

All patients with radiological signs of appendicitis, or with high clinical suspicion of appendicitis, were operated within a few hours after the MRI studies. The pathological criteria for acute appendicitis was the presence of polymorphic granulocytes.
throughout the appendiceal wall including the muscularis [7]. Patients who did not undergo surgery were followed clinically until delivery.

Results

The median time from onset of symptoms to admission was 24 hr (range, 6–48 hr). The median body temperature, leukocyte count, and erythrocyte sedimentation rate on admission were 37.8°C (range, 37.2–38.5°C), 13 x 10^3/µL (range, 5.9–18.8 x 10^3/µL), and 30 mm/hr (range, 5–50 mm/hr), respectively. The median age of the patients was 28 years (range, 18–34 years), and the median gestational age of the fetus was 17 weeks (range, 7–35 weeks).

Sonography did not detect the appendix in 11 of the 12 patients in the study, nor did it detect inflammatory changes in the region where the appendix was expected to be located. In four patients the sonographic studies showed moderate hydronephrosis on the right side. In one patient with a fetus at 13 weeks' gestation, the sonographic study showed an inflamed appendix.
The MRI studies showed a normal appendix in seven patients (gestational ages of 7, 12, 17, 22, 23, 28, and 31 weeks) and were suggestive of appendicitis in three patients (gestational ages of 11, 13, and 16 weeks). In two patients the appendix was not seen on MRI (gestational ages of 17 and 35 weeks). Neither the sonography nor the MRI studies showed any complications such as abscesses, signs of perforation, or ileus. In the three patients with positive MRI findings, the appendix appeared as a blind-ended tubular structure (Figs. 1-3). The lumen had high signal intensity on the T2-weighted and fat-suppressed images and a low signal intensity on the T1-weighted images. The appendiceal wall was hypointense on the T1-weighted images and slightly hyperintense on the T2-weighted images. The surrounding fatty tissue had high signal intensity on the T2-weighted and fat-suppressed images and low signal intensity on the T1-weighted images, representing the inflammatory changes in the surrounding fatty tissue. When the appendix was seen in its short axis, a typical target sign was seen (Figs. 3). All three patients underwent emergency laparotomy, and the diagnosis was confirmed at the time of surgery and later with pathologic investigation.

Seven patients had a normal-appearing appendix on MRI in the form of a blind-ended tubular structure with a diameter less than 6 mm, with low signal intensity on both T1- and T2-weighted images and without signs of periappendicitis (Fig. 4). Of the nine patients in whom MRI did not show an inflamed appendix, four had signs of hydronephrosis and hydroureter on the right side; and in two of these patients, the appendix was not seen on MRI. MRI clearly showed that the hydronephrosis and hydroureter were the result of the uterus compressing the right ureter where it crosses the right iliac vessels. This is a known phenomenon in pregnancy and normally requires no treatment [8]. However, one patient had a moderate hydroureter and hydronephrosis on the right side and a left kidney that was small and showed cystic degeneration. Because of deterioration of renal function, a double J catheter was placed in the right ureter, after which the symptoms quickly subsided. The follow-
Fig 2. 33-year-old woman, 13 weeks pregnant, with two days of right lower quadrant pain and clinically suspected appendicitis. Coronal (a) and axial (b) T2-weighted images shows an enlarged appendix (white arrow) surrounded by a hyperintense mass of inflamed fat (arrowheads). The enlarged uterus is also seen (black arrow in a,b,c,d). The inflammatory changes around the appendix are clearly seen as areas with high signal intensity (arrowheads) on the T2-weighted coronal image (c) with fat-suppression. On this image the appendix itself is not clearly seen. Axial T1-weighted image (d) shows the inflammatory changes around the appendix as a low signal intensity mass (arrowheads), the appendix itself could not be depicted within this mass. Appendectomy was performed and a non-perforated gangrenous appendix was removed.
up of the other three patients showed a general improvement of symptoms, and no other diagnosis emerged in time. The MRI examination did not indicate an alternative diagnosis in the other five patients. The symptoms subsided in these patients, and the discharge diagnosis was nonspecific abdominal pain. No postoperative or perinatal complications appeared, and all patients vaginally delivered healthy neonates at term.

No new findings were made during the retrospective review of the MRI studies that were not detected in the initial prospective evaluations.

**Fig 3.** 30-year-old, 16 weeks pregnant woman with clinically suspected appendicitis. **a.** Axial T2-weighted image (a) shows the enlarged appendix (arrow), the appendix is in a retrocecal position. Axial T1-weighted image (b) shows the inflamed appendix (arrow) with some hypointense fat-stranding in the surrounding fat. Coronal T2-weighted image (c) shows part of the inflamed appendix (white arrow) as well as the enlarged uterus (black arrow).
Discussion

Acute appendicitis is the most common surgical emergency in pregnancy. The diagnosis can be difficult because these patients rarely present with classic symptoms such as anorexia, fever, nausea, vomiting, and periumbilical pain localizing to the right lower abdominal quadrant. Laboratory findings such as leukocytes or elevated erythrocyte sedimentation rates are unreliable parameters during pregnancy [3]. The enlarged uterus can displace the appendix superiorly and elevate the anterior peritoneum, which hampers a proper physical examination; as a result, preterm labor and delivery can occur before an acute abdomen presents [1, 2]. In addition, laparotomy can cause surgical complications and lead to preterm delivery [1, 2]. A correct diagnosis allows the use of a special small incision to detect and localize the inflamed appendix, instead of a large vertical incision to allow extensive exploration when multiple diagnoses are entertained. This procedure can be especially useful in pregnant women [9].

In pregnant women the enlarged uterus can alter the position of the abdominal contents, and thus make sonography and clinical diagnosis more difficult [1-3]. In our study, sonography could not visualise the appendix in 11 of 12 patients, partly because of obesity and partly because of the large gravid uterus, making the graded

![Fig. 4. —32-year-old woman in 17th week of pregnancy with right lower quadrant pain and clinically suspected appendicitis. Coronal T2-weighted image shows retrocecal normal-sized appendix (arrow) without inflammatory changes. Gravid uterus (arrowhead) is visible as well.](image)
compression technique more difficult, especially when the appendix is in a retrocecal position. CT can be performed in such cases, but it involves a considerable amount of radiation. A typical dose for an abdominal CT examination is in the order of 10mSv [10].

The routine use of diagnostic CT examinations for benign diseases, as in appendicitis, raises the question whether the diagnosis can be obtained by other radiological means, especially in pregnant women and even more when the fetus is in the direct beam. The international commission on radiological protection (ICRP) recently published a report on radiation and pregnancy. They recommended that if the expected dose for the fetus is high, one should question if the diagnosis could be obtained without using ionizing radiation [11]. An abdominal MRI examination of the abdomen appears to be a good alternative. No known biological risks are associated with MRI. To our knowledge, no delayed sequelae from undergoing or performing MRI examinations have been encountered, and it is expected that the risk of delayed sequelae is extremely small. However, unknown bioeffects may exist, and extra caution is urged when using MRI in the first trimester, a time of organogenesis, when the fetus might be more vulnerable to any unknown effects of MRI. The risk of exposing the developing fetus to any radiologic diagnostic imaging technique that uses ionizing radiation is probably greater than the theoretical risk of MRI. According to the Safety Committee of the Society for Magnetic Resonance Imaging, MRI is indicated for use in pregnant women when the result of nonionizing diagnostic imaging is inadequate for diagnosis or when MRI is expected to provide important information for proper treatment of the fetus or mother [12]. However, pregnant women should be informed that the safety of MRI procedures during pregnancy has not been definitively proved. [12].

MRI has a number of advantages over CT. First, MRI does not require contrast material, thus minimizing patient discomfort and possible systemic adverse reactions, whereas CT often requires intravenous, rectal or oral contrast material. Second, with
MRI the entire abdomen can easily be viewed in more planes. Finally, MRI reduces possible psychologic pressures in this group of pregnant women, because they do not have to worry about the effect of potentially hazardous radiation exposure to the fetus.

In this series of pregnant women suspected of having appendicitis, MRI accurately detected three cases of appendicitis. In the other nine patients, MRI did not show appendicitis. The absence was confirmed on the basis of clinical follow-up and operative intervention was avoided. The three positive cases were identified when their fetuses were at 11, 13 and 16 weeks’ gestational ages. The normal appendix was visualized in patients when their fetuses were at 7,12,17,22,23,28,31 gestational ages weeks’ respectively; and the appendix was not seen in two patients when their fetuses were at 17 and 35 weeks’ gestational age respectively. Only three patients were studied in the third trimester of pregnancy, and the appendix was seen in two of these three. Although we are dealing with a small number of patients, our results suggest that MRI, is somewhat more accurate in early pregnancy than in late pregnancy.

In conclusion, abdominal MRI is a valuable and safe technique for the evaluation of pregnant patients clinically suspected of having acute appendicitis. Unnecessary operations can be avoided when a normal appendix is identified.
References